ANNOTATED BIBLIOGRAPHY OF HUNGARIAN POTTERY ARCHAEOMETRICAL STUDIES

Compiled by the authors and incorporating references in ARH vols. I-II.

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KULCSSZAVAK: KERÁMIA, ANYAGVIZSGÁLAT, ARCHEOMETRIA, BIBLIOGRÁFIA

KEYWORDS: CERAMICS, ANALYSES, ARCHAEOMETRY, BIBLIOGRAPHY

ARH I. = JÁRÓ M., KÖLTŐ L., eds. (1988): Archaeometrical research in Hungary. National Centre of Museums, Budapest, pp. 1-327.

Collective volume on current Hungarian archaeometrical research with annotated bibliography.

ARH II. = KÖLTŐ L., BARTOSIEWICZ L., eds. (1998): Archaeometrical research in Hungary II. Budapest-Kaposvár-Veszprém, pp. 1-323.

Collective volume on current Hungarian archaeometrical research with annotated bibliography.

BAJNÓCZI, B., TÓTH, M., MERSDORF, ZS. (2005): Kerámiák vizsgálata katódlumineszcens mikroszkóppal zalavári - kora középkori - leletek példáján/Cathodoluminescence microscopy study of pottery from Zalavár (Migration Period, Hungary). *Archeometriai Műhely* (electronic periodical: http://www.ace.hu/am/index.html), **2005/2**, pp. 31-41. (in Hungarian with English abstract).

The paper describes the possibility of using cathodoluminescence (CL) microscopy for petrographic study of archaeological pottery objects. CL microscopy shows more details than conventional polarized light microscopy about the inner structure and chemistry of aplastic components of pottery products as well as the texture of the samples. It enables to reveal differences in the mineralogy of aplastic components, and characteristic minerals as "fingerprints" may allow distinguishing potteries of different provenance and origin.

The pottery vessels studied by CL method are from Zalavár-Városziget (W-Hungary) and derive from the second half of the 9th century AD. Most of the products were fired on less than 650°C. This relatively low temperature doesn't really affect aplastic components, therefore enables their petrographic study using CL method combined with X-ray diffraction. In addition to the common calcite and feldspar detritus and quartz-bearing fragments, part of the samples contains several mm large, rounded, dolomite-bearing lithofragments (pebbles), which are supposed to be tempering material. Dolomitic rock fragments are distinguished from angular calcite grains with dull to very bright luminescence by their non- or very weak CL. Local sediments contain dolomite only in limited amount. Therefore we suppose that the dolomitic-bearing ceramics probably were not made locally, but "imported" from nearby regions around Zalavár-Városziget.

BALLA, M. (2005): Beyond style. A provenance study of Iznik pottery by means of NAA. *In: Turkish flowers. Studies on Ottoman Art in Hungary (ed. I. Gerelyes)*. Hungarian National Museum. pp. 63-68.

A set of Iznik pottery as well as Habaner faiance and wall-tile samples from different Hungarian settlements were analysed to find evidence, if any, for their common provenance.

BALLA, M., BÉRCZI, J., KEÖMLEY, G., ROSNER, GY., GABLER, D. (1989): Provenance studies of ceramics by NAA. *ARH* **I.**, pp.103-118.

The implementation of the NAA method is summarized in this paper. The analytical protocol, the standardization method, uncertainty budget calculation, homogeneity studies and data procession techniques are treated. By applying the developed methods, specific archaeological problems of terra sigillata and Avar potteries are tackled.

BALLA, M., GABLER, D. (1983): Terra sigillaták eredetének vizsgálata neutronaktivációs analitikai módszerrel. (Provenance study of Terra sigillata by the means of neutron activation analysis). *Arch. Ért.,* **109** pp. 74-80. (in Hungarian).

Products from the most important terra sigillata firms that exported pottery to Roman Pannonia have been investigated. The analysis of authentic workshop material has permitted spatial and temporal studies of the distribution of these ceramics.

BALLA, M., GUNNEWEG, J. (2007): Archeological research at the Institute of Nuclear Techniques, Budapest University of Technology and Economics: scholarly achievements of a prosperous long-term collaboration. *Archaeometry* **49, 2**. pp.373-381.

This paper is one of the series of reports that document the 50 years history of NAA applied to archaeological materials. In this Special issue of Archaeometry, laboratories summarize the site-specific characteristics of the NAA method. The history of the laboratory is treated, facilities and instrumentation are shown, laboratory staff introduced. Besides, areas of archaeological research are given and the comprehensive Qumran pottery project is presented as a typical example of archaeological activity.

BALLA, M., KEÖMLEY , G., ROSNER, GY. (1990): Neutron activation analysis for provenance studies of archaeological ceramics. *J. Radioanal. Nucl. Chem*. **141**. pp. 7-12.

A provenance study of ninth-century Avar pottery from the Transdunabian part of Hungary resulted in the identification of multiple contemporaneous production centres, which manufactured ceramic of the same style. These ceramics also have been documented in nearby cemeteries.

BALLA, M., ZSIDI, P., BALÁZS, L. (1999): Spread of mortaria types in Municipium Aquincum (Óbuda, Hungary). *J. Arch. Sci*. **26**, pp. 997-1001.

Grinding bowls from Aquincum, the capital of Pannonia Inferior have been analysed by NAA. Questions, related to the manufacture and marketing of Aquincum mortars were undertaken, and the distribution of the products within the local market and proof of long-distance commerce has been established.

BENKŐ, L. (1977): Contribution a la datation des céramiques par thermoluminescence. *Acta Arch. Hung.*, **23**, pp. 203-207.

A simple and rapid TL technique was elaborated to date potteries of archaeological origin. Grains from the whole material were used TL measurements. To access the beta dose-rate, $CaSO_4$: Dy phosphor was mixed with clay powder. A few weeks of exposure were enough to evaluate the beta dose-rate. 15 sherd fragments were studied and for most of them the obtained TL age was found to be within 20 per cent of the archaeological age. (from ARH I.).

BENKŐ, L. (1979): Kányaszurdoki leletek keltezése termolumineszcens módszerrel (TL dating of some finds from Kányaszurdok). *Arrabona*, p. 107. (In Hungarian).

Fragments of ancient smelting hearth from the site Kányaszurdok were dated by thermoluminescence, XRF, alpha-counting and TL dosimetry were used for dose-rate determinations. The obtained ages are 1190 and 1263 years BP, with a realistic estimate of +20…-10% overall uncertainty, mostly due to incomplete information about burial conditions. (from ARH I.).

BENKŐ, L. (1981): Termolumineszcens kormeghatározás: az alkalmazás lehetőségei kohók esetében (Thermoluminescence dating possible applications to ancient ovens). *MTA VEAB Értesítő*, Veszprém**,** p. 205. (In Hungarian).

Physical principles of the thermoluminescence dating are discussed. Application possibilities related to ancient ovens are outlined, as well as some preliminary results. Specific instructions are given conceming the collection of pottery samples to be dated. (from ARH I.).

BENKŐ, L. (1984): A Sopron, Május 1. téri vasolvastó kemence TL vizsgálata (TL dating of an iron-smelting furnace found in the Roman cemetery of Scarabantia). *MTA VEAB Értesítő*, Veszprém**,** p. 263. (In Hungarian).

The built-in type furnace was excavated in the South cemetery in 1952. Its archaeological date is the 3rd century A.D. The TL dating gives an earlier age than the early medieval furnaces of this type. It is probably of Roman Imperial period. (from ARH I.).

BENKŐ, L. (1984): Kemencék és edények vizsgálata TL módszerrel (TL dating of

potteries, furnaces and kilns). *MTA VEAB Értesítő*, Veszprém, p. 263. (In Hungarian).

A number of experiments were carried out with archaeological quartz samples of various transparency and also with selected shiny and frosty grains. Some correlations with TL characteristics are discussed. The dating technique and a few applications to kilns, furnaces and Copper Age potteries are presented. (from ARH I.).

BENKŐ, L. (1985): Thermoluminescence dating: Recent developments and applications in Hungary. *Mitt. Arch. Inst.*, **14**, pp. 307-312.

A couple of important sites on the Hungarian Plain were selected for the TL programme. Experimental results are presented on the TL properties of pottery quartz grains originating from these sites. Measurements were performed with a special Harshaw 2000 analyser. The samples were linearly heated up to about 500 °C at a rate of 10 °C/s and, when needed, a pre-heat at 280 to 320 °C was applied for 20 to 30 seconds. Taking into account the observations related to transparency effects, the potteries from the Copper Age cemetery at Tiszapolgár-Basatanya were investigated. Some of our results agree with the calibrated radiocarbon ages and show that the site is probably older than supposed by means of conventional methods. (from ARH I.).

BENKŐ, L. (1986): Propress of TL dating in Hungary. *Acta Interdisciplinaris Archaelogica*, Nitra, pp. 161-169.

The TL technique used for the dating of potteries is presented. Instrumentation, sample preparation and dosimetry problems are outlined. Taking into account the effects of transparency differences of quartz grains, the experience and TL dates obtained with a number of potteries from a Copper Age cemetery on the Hungarian Plain are discussed in detail. (from ARH I.).

BENKŐ, L. (1988): A soproni vörössánc anyagának termolumineszcencia- vizsgálata (TL dating of the earthwork at Sopron). *Soproni Szemle*, **XLII**, p. 125.

Attempts to date a burned red mound by physical (radiocarbon, archaeomagnetic and thermoluminescence) methods are reported. (from ARH II.).

BENKŐ, L. (1988): Thermoluminescence dating of Hungarian archaeological sites (potteries, hearths, calcite). In *M. Járó, L. Költő eds.: Archaeometrical Research in Hungary*, National Centre of Museums, Budapest, p. 71.

Procedures and applications are discussed to date pottery and finds produced by industrial archaeology. Results related to materials of geological origin (calcite) are presented. (from ARH II.).

BENKŐ, L. (1993): Datation par thermoluminescence des sites préhistoriques dans le Bassin des Karpaths. *Proc. XIIth IUPPS Congress*, Bratislava, p. 108.

Some 50 TL dates representing the period from the Early Neolithic to the Late Bronze Age are discussed. (from ARH II.).

BENKŐ, L. (1994): Kerámiákban levő kvarckristályok termolumineszcens tulajdonságainak vizsgálata és alkalmazásuk a kormeghatározásban (Thermoluminescence properties of pottery quartz crystals, and their application in dating. Thesis.). Dissertation, MTA Izotópkutató Intézete, Budapest, (In Hungarian). (from ARH II.).

BENKŐ, L., BOGNÁR-KUTZIÁN, I**.** (1988): Investigation of two Copper Age cultures by means of TL dating. *Nucl. Tracks Radiat. Meas.*, **14**, p. 287.

The largest Copper Age cemetery in Hungary was studied in detail. 26 vessels from 15 graves were investigated by quartz inclusion technique. TL analyses revealed two distinct periods, correspondig to the Tiszapolgár and Bodrogkeresztúr cultures, with TL ages of 6380+-160;+-500 and 5830+-100;+-450 yr, respectively. (from ARH II.).

BENKŐ, L., HORVÁTH, F., HORVATINCIC, N., OBELIC, B. (1989): Radiocarbon and thermoluminescence dating of prehistoric sites in Hungary and Yugoslavia. *Radiocarbon*, **31**, p. 992.

Radiocarbon and thermoluminescence measurements were taken to date two tell settlements in the Carpatian basin: the Late Neolithic site Gorzsa (southeast Hungary) and the Eneolithic site of Vučedol (east Croatia). The TL ages range from 4900 to 4500 BC and 3600 to 2900 BC, respectively. (from ARH II.).

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BEZECZKY, T. (1985): Archaeometric investigation of Roman amphoras from Pannonia. *Industrial Archaeology and Archaeometry Newsletter / English Supplement*, **4**, p. 2.

A brief description of the archaeometric analysis of Pannonia amphorae.

BEZECZKY, T. (1985): P.Iturius amphorája Vetus Salinában (P. Iturius Sabinus' amphora from Vetus Salina). *Folia Arch.*, **36**, pp. 69-74. Józsa, S. and Szakmány, Gy.: Az amphora petrológiai vizsgálata, p. 73.

The workshop producing olive oil from the later 1st century AD was owned by Publius Iturius Sabinus, who probably had estates near Capodistira in northern Istria. A Dressel 6B amphora from his workshop was found in the Roman fort at Vetus Salina on the Danubian limes. The petrological analysis based on a thin section from this amphora was the first in the research of Istrian amphorae. The analyses indicated that in addition to quartz, muscovite and biotite, the fabric contained also sericite-calcite inclusions.

BEZECZKY, T. (1986): Le anfore. In: Gabler, D., Redő, F. (eds.): Gli Scavi nalla villa Romana a S. Potito (Ovindoli) 1983-84, *Acta Arch. Hung.*, **38**, pp. 79-86. Józsa, S. and Szakmány, Gy. Analisi petrologico di anfore, p. 86.

A Roman villa was excavated near S. Potito, a small village in central Italy. The finds from the villa lying among the hills on the territory belonging to Alba Fuces included several Italian (Dressel 2-4) and Aegean wine (Dressel 5 and Rhodian) amphorae, Baetican (Dressel 20) olive oil amphorae and southern Spanish (Dressel 7-11) garum amphorae. Amphorae assigned to the Haltern 70 type were also found (these are now assigned to the Dressel 14 type, produced in the Sado Valley in Portugal). Different fabric types could be distinguished based on petrological analyses.

BEZECZKY, T. (1987): Roman amphorae from the Amber Route in Western Pannonia. *BAR, International Series*, **386**, Oxford, Supplement 1, Józsa, S. and Szakmány, Gy.: Petrology, pp. 103-124; Iváncsics, J.: Schörgendorfer 558 amphora, pp. 125-127; Weiszburg, T. and Papp, G.: X-ray powderdiffraction analyses, pp. 128-133; Iváncsics, J.: X-ray diffraction (Schörgendorfer 558 amphora), pp. 134-135.

The book offers an overview of the amphorae brought to light in the Roman military forts and settlements along the Amber Road (from Nauportus to Carnuntum), an ancient trade route. A detailed petrological analysis of the Dressel 2-4, Dressel 5, Dressel 6B, Schörgendorfer 558, Porto Recanati és Dressel 20 amphorae are included. For the first time, the various amphora types produced in Istrian workshops are discussed in detail. These include the pieces produced in the Laecanius workshop in Fažana, the Calvia Crispinilla workshop in Loron and the Dressel 6B amphorae bearing imperial stamps. Schörgendorfer 558 and Porto Recanati type amphorae are similarly analysed exhaustively. The thin sections offer additional information on the different amphora types. The XRD analyses indicate the temperate at which these vessels were fired. Although the two Istrian workshops produced identical Dressel 6B amphorae, these can nonetheless be distinguished by their fabric, even though the fabric of the pieces is not homogenous. In contrast to earlier assumptions, Schörgendorfer 558 amphorae were not produced on the Istrian peninsula. An analysis of the finds from an unexcavated amphora workshop in Loron near Porec based on thin sections is also included.

For a detailed petrological analysis see: JÓZSA, S., SZAKMÁNY, Gy. (1987): WEISZBURG, T., PAPP, G. (1987)

BEZECZKY, T. (1988): A Borostyánkő út amphoraleletei. *Arch. Ért.*, **114-115** (1987-1988), pp. 156-182.

An overview, in Hungarian, of the earlier study on the amphora finds found along the Amber Road and their petrological analyses.

BEZECZKY, T. (1990): Amphorák az adonyi (Vetus Salina) korarómai táborból. (Amphorae from the auxiliary fort of Adony (Vetus Salina)). *Arch. Ért.*, **117** (1990), pp. 96-102. Józsa, S., and Szakmány, Gy.: A vetus salinai amphorák petrográfiai vizsgálatának eredményei, Fig. 5. 100.

A study on the wine (Rhodian), olive oil (Dressel 6B and Dressel 20), and garum amphorae (Dressel 7-11, Pelichet 46) found in the Roman fort at Vetus Salina on the Danubian limes, together with a detailed petrographic analysis of the eleven published amphorae.

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BEZECZKY, T. (1993): Knidische Amphoren in den nördlichen Provinzen des römischen Reiches. *Carinthia*, **183**, pp. 237-244. Józsa, S, és Szakmány, Gy. Perologische Eigenschaften, pp. 242-244.

Cnidian amphora fragments have been found at Magdalensberg, an important trading centre in Noricum, a region where finds of this type are quite rare. Lying on the Datcha peninsula in Asia Minor, Cnidos was famed for its wine during the Hellenistic and Roman period. A stamp depicting a theater mask can be seen on the amphora handle of one fragment from Magdalensberg. In addition to the handle fragment, the finds included also base fragments. Cnidian amphorae are known from Pannonian sites (Savaria and Salla) too. These section analyses revealed that the fabric contained serpentinite and augite, two inclusions typical for the Cnidian wares.

BEZECZKY, T. (1994): Amphorenfunde vom Magdalensberg und aus Pannonien, Ein Vergleich. *Archäologische Forschungen zu den Grabungen auf dem Magdalensberg*, **12**, Klagenfurt. Mit einem mineralogischpetrographischen Beitrag von S. Józsa, R. Sauer, G. Szakmány und T. Weiszburg, pp. 143-166.

The occupation of Pannonia and the organisation of its administration was for a long time the subject of heated discussions. According to one view, the entire territory of Pannonia was occupied under Augustus, while according to another, only the Drava and Sava valleys were occupied under Augustus, followed by the Amber Road, along which a chain of military camps was built. The administration of the province was organised under Claudius, when the borders too were fixed. The foods transported in the amphorae can be linked to the military and the Italian merchants. The distribution and chronology of the amphorae reflects the gradual occupation of the province.

For a detailed petrological analysis see: JÓZSA, S., SAUER, R., SZAKMÁNY, Gy., WEISZBURG, T. (1994)

BEZECZKY, T. (1996): Documentation and description method of Roman amphorae, typological analyses with the application of mathematical statistics. In *E. Marton (ed.): The Future of our Past '93-'95*, Budapest, pp. 60-71. (from ARH II.).

BEZECZKY, T. (2002): Early Roman Food Import in Ephesus: Amphorae from the Tetragonos Agora. In: Transport Amphorae and Trade in the Eastern Mediterranean, Acts of the International Colloquium at the Danish Institute at Athens, September 26-29, 2002, J. Eiring and J. Lund (eds.), Athens, 2004, pp. 85-97.

Ephesus was one of the five wealthiest Mediterranean towns from the age of Augustus. The study offers an overview of the early Roman amphorae and of the database, which also contains entries for the description of the fabric, together with a macroscopic description and photomicrographs of the fresh brakes surfaces (magnification 20x times).

The updated version of the computer database programme (ARES, based on FileMaker Pro and ArchiCad softwares) contains fields for the descriptions of the thin sections, photos of the most typical components and the data of the heavy mineral analyses.

BEZECZKY, T. (2005): Roman Amphorae from Vindobona. In: *Krinzinger, F. (Hrsg.): Vindobona. A. Forsch., 12, Denkphil* Wien, **328**, pp. 35-108. Sauer, R.: Ergebnisse der mineralogisch-petrographischen Analysen von augewählten römischen Amphoren au Wien, pp. 109-142.

An analysis of Dressel 2-4, Dressel 43 (Cretoise AC4), Rhodian, Knidian, Kapitän II, Gauloise 4, Forlimpopoli, Dressel 6B, Dressel 20, Schörgendorfer 558, Dressel 7-11, Beltran I, Beltran II A, Beltran IIB, Camulodunum 189, Porto Recanati, Aquincum 78, Bónis XXXI/5 amphorae. Most amphora types were submitted to thin section and heavy mineral analyses. One new research result is that R. Sauer has identified the place of manufacture of Schörgendorfer 558 and Porto Recanati type amphorae in the Lake Garda area.

BEZECZKY, T. (2005): Roman amphorae: a digital resource. In: *Roman Amphorae: a digital resource*, University of Southampton, 2005, Project Manager Simon Keay, Project Supervisor David Williams.

The amphora database available on the Internet contains the full description of the Aquincum 78, Bonis 31/5, Brindisian amphora, Dressel 6A, Dressel 6B, Dressel ante 6B, Dressel 25, Lamboglia 2, Porto Recanati, Schörgendorfer 558 amphorae and a visual and petrological description of their fabric, as well as a full bibliography.

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BEZECZKY, T., FLOS, G. (1993): Hispanici. *Ptujski Arheoloski Zbornik*, ob 100-letnici muzeja in Muzejskega drustva, pp. 241-250. Józsa, S, és Szakmány, Gy. Petrological Characteristics, 245, Fig. 3.

Southern Spanish amphorae with painted inscription are rare finds in Pannonia. The inscribed amphorae from Poetovio and Magdalensberg had contained fish sauce (garum). The study discusses the origins of these amphorae based on the epigraphic and petrographic evidence.

BIRÓ, K. T., GHERDÁN, K., SZAKMÁNY GY. (2007): Ceramic sequence of 7000 years: archaeometrical study of pottery finds from Vörs, Máriasszony sziget (SW Hungary). In: Waksman, Y. ed., Archaeometric and Archaeological Approaches to Ceramics. Papers presented at EMAC '05, 8th European Meeting on Ancient Ceramics, Lyon 2005. *BAR International Series*, Oxford **1691** 25-31

The site considered in this study is a multi-period archaeological site, spanning from the Early Neolithic (around. 5500 BC) to the Early Mediaeval Conquest period. The village lies in Southwest Hungary, near Lake Balaton. The exceptionally favourable environmental endowments of the territory offered an ideal setting for habitation. Sites and finds from almost all periods of prehistory were found here, rich till the historical ages. The pottery assemblage of the locality at Máriaasszonysziget, a sandy peninsula protruding into the former lake, provided a good possibility for a diachronic study of changes in raw material selection and pottery manufacture.

The experiences of Vörs pottery analysis serve as a starting point for ceramic archaeometry studies for archaeological assemblages over a wide area and an essential time span.

CHRISTOVA, B. G., BENKŐ, L., PETŐ, Á., SHIRAKOVA, E. B. (1993): TL dating of Early Neolithic pottery sherds found in the Slatina region, Bulgaria. *Proc. XIIth IUPPS Congress*, Bratislava, p. 114.

The paper reports on the first results of TL dating performed in the Institute for Nuclear Research and Nuclear Energy, Sofia. Results obtained by the fine grain technique and the quartz inclusion technique are discussed. (from ARH II.).

ELEKES Z., T. BIRÓ K., UZONYI I., SIMON A., KISS Á. Z. (2001): Analysis of prehistoric pottery finds from the Balaton region, Hungary. *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*, **181**, 670-X./ 1.1812005.

Analysis of pottery fragments from an intensively studied Hungarian archaeological site, Vörs-Máriaasszonysziget is detailed in this work. Fragments of pottery from different closed archaeological units with various ages were studied. Correlation between the bulk and microscopic contents of the samples and the raw material source and/or preparing technique for the vessels is discussed. The analytical investigations were taken at the Institute of Nuclear Research of the Hungarian Academy of Sciences (ATOMKI) by micro-PIXE method using two Si(Li) detectors simultaneously.

GHERDÁN, K., SZAKMÁNY, GY., WEISZBURG, T., ILON, G. (2002): Petrological Investigation of Bronze and Iron Age Ceramics from West Hungary: Vaskeresztes, Velem, Sé, Gór. In Kilikoglou, V., Hein, A., Maniatis, Y. eds.: Modern Trends in Scientific Studies on Ancient Ceramics, *BAR International Series 1011*, Oxford, pp. 305–312.

Ceramics of four Bronze and Iron Age sites at the foothills of the Eastern Alps in West Hungary were subjected to petrographic analysis. The four sites represent four geomorphologically different territories: two can be found in the mountains, one in a piedmont and one on a plain. River terraces are covered with clayey, sandy, gravelly sediments containing rock fragments of the rivers' gathering grounds. Based on petrographic analysis of the tempering material the source area of the rock types could be identified.

GHERDÁN, K., T. BIRÓ, K., SZAKMÁNY, GY. (2004): Petrologic studies on Early Neolithic Pottery from Vörs, SW Hungary. *Acta Mineralogica-Petrographica*, **XLV/2**, Szeged, pp. 41–48.

This study presents the preliminary results of the petrographic investigation of Neolithic pottery from Southwest Hungary, Vörs. The 17 samples examined represent the most important habitation period of the site, the Early Neolithic Starčevo Culture. In most cases organic material was used deliberately as temper. Other non-plastic inclusions involve

mineral grains and rock fragments (argillaceous rock fragments, sandstone grains, mica-schist fragments, other metamorphic rock fragments and in one case volcanic rock fragments), clay pellets and in one case, grog fragments.

GHERDÁN, K., T. BIRÓ, K., SZAKMÁNY, GY., TÓTH, M. (2005): Technological investigation of Early Neolithic pottery from Vörs, southwest Hungary. In: *Prudêncio, M. I., Dias, M. I., Waerenborgh, J. C. (eds.): Understanding People through their Pottery.* Proceedings of the 7th European Meeting on Ancient Ceramics, Lisboa, pp. 103–108.

Previous pottery groups defined by petrographic methods were refined with the help of geochemical analysis. Geochemical analysis confirmed the existence of two major groups. Coeval samples from a nearby settlement, Szentgyörgyvölgy were used for comparison. X-ray powder diffraction analysis showed that sandwich ceramics were fired at relatively low maximum temperatures (750ºC), with short soaking time (presence of chlorite in the inner part, its absence in the outer part) and high heating rate.

GHERDÁN, K., T. BIRÓ, K., SZAKMÁNY, GY., TÓTH, M.; SÓLYMOS, K.G. (2005): Analysis of incrusted pottery from Vörs, southwest Hungary. In: *Prudêncio, M. I., Dias, M. I., Waerenborgh, J. C. (eds.): Understanding People through their Pottery.* Proceedings of the 7th European Meeting on Ancient Ceramics, Lisboa, pp. 103–108.

Previous investigations showed that the incrustation material of samples from the Late Copper Age, Kostolac culture and from the Early Bronze Age Kisapostag culture of the site have high phosphorus and calcium content. In this study, with the help of X-ray powder diffraction analysis, it was proved that the material used for the decoration was hydroxyapatite.

GÖMÖRI, J., MÁRTON, P., HERTELENDI, E., BENKŐ, L. (1994): Sopron és Darufalva (Drassburg) égett sáncainak kormeghatározása fizikai módszerekkel (Dating of Hungarian earthworks by physical methods). *Arrabona* (Győr), **31-33**, p. 49.

Radiocarbon, archaeomagnetic and thermoluminescence techniques were used to assess dates of construction and life-span of two burned red mounds. (from ARH II.).

GUNNEWEG, J., BALLA, M. (2001): How neutron activation analysis can assist research into the provenance of pottery at Qumran. *In: Historical perspectives: from the Hasmoneans to Bar Kokhba in light of the Dead Sea Scrolls. (eds. D.Godblatt, A. Pinnick and D.R. Swartz), Proceedings of the Fourth Int. Symp. Of the Orion Center, 27-31 January 1999.* E.J. Brill, Leiden, pp. 179-185.

The origin of the Dead Sea Scrolls has remained an enigma, as have the people who wrote these scrolls. This paper aimed at tracing the provenance of the pottery of Qumran, including the "scroll jars" in which the scrolls were apparently found. Special attention was given to a jar, with ROMA inscription.

GUNNEWEG, J., BALLA, M. (2002): Instrumental neutron activation analysis, Busayra and Judah. *In: Busayra, excavations by Crystal-M. Bennet (ed. P. Bienkowski), British Academy Monographs in Archaeology* **13.** Oxford University Press, Oxford. pp. 483-487.

The paper focuses upon the determination of the chemical fingerprint of Busayra local ware, in order to establish the relation between the pottery found at Busayra and in other Edomite sites, and to study the character of an interregional trade between Busayra and surroundings.

GUNNEWEG, J., BALLA, M. (2003): Neutron activation analysis: scroll jars and common ware. *In: Khirbet Qumran and 'Ain Feshkha II. Studies of anthropology, physics and chemistry (eds. J.-B. Humbert and J. Gunneweg)*, Academic Press/Vandenhoecken & Ruprecht, Fribourg, Göttingen. pp. 3-55.

Qumran's unique cultural heritage has been studied from many different angles to better understand the spiritual and material inheritance of the Dead Sea Scrolls and the Qumran community. A multidisciplinary project is going on in Qumran, to study the site and its people by using scientific methods, among them NAA. Neutron activation analysis has been applied to ceramics from the settlement and the surrounding caves, to trace Qumran ceramics to their site-specific

manufacture centers and to define trade patterns and interregional contacts.

HEROLD H. (2003): Die awarenzeitliche Keramik von Zillingtal im Burgenland (Österreich) – eine archäologische und naturwissenschaftliche Analyse. (The Avar Period ceramic finds from Zillingtal in Burgenland (Austria) – an archaeological and archaeometric analysis – in German). *Bodendenkmalpflege in Mecklenburg-Vorpommern*, Jahrbuch 2002, Band **50**, Lübstorf, pp. 281-292.

The ceramic finds of the early medieval settlement and cemetery excavated in Zillingtal (Burgenland, East-Austria, 7-8th century AD) were analysed parallel to the archaeological investigations, by thin section analysis, X-ray diffraction analysis and by methods of experimental archaeology. The main goals of the analysis were: to elaborate the chronology of the ceramic vessels, to analyse the production structures of the Avar Period ceramics and to investigate their provenance and possible function(s).

On the basis of examinations of both the settlement- and cemetery ceramics two main types of ceramics could be distinguished: hand made pottery and pottery turned on a slow wheel. These two main types existed parallel in time and can be divided into 4 and 3 smaller, chronologically relevant groups. The existence of these groups can also be shown using scientific methods, such as thin section analysis. Laboratory and field experiments with clay samples from the site, combined with scientific analyses (thin section analysis, X-ray diffraction analysis) indicated the local origin of both hand made and slow-wheel turned ceramics. With field experiments it could be demonstrated that hand made, non-tempered pots made of clay local to the site can be used for cooking on open fire.

HEROLD H. (2003): Die Keramik der Randgebiete des Awarischen Khaganats unter besonderer Berücksichtigung der Siedlung und des Gräberfeldes von Zillingtal (Burgenland). (The ceramic finds of the periphery of the Avar Khaganate with a special emphasis on the settlement and cemetery of Zillingtal (Burgenland) – in German). *Archäologisches Nachrichtenblatt*, Band **8, 3/2003**, Akademie Verlag, Berlin, pp. 278-279.

The excavated section of the settlement in Zillingtal includes a Roman Villa with destruction layers and postholes from the Avar Period. It also contains remains of a building with post-construction, some pits and iron smelting furnaces from the same age (in the vicinity of the Villa). The cemetery, which belonged to the settlement, was excavated 1200 m west of the settlement. The fully excavated cemetery has nearly 800 graves. There are ceramics in about 90% of the graves – usually one pot per grave.

The ceramic finds from the settlement and the cemetery of Zillingtal were analysed with archaeological and archaeometric methods. This article gives a brief summary on the main results of the project.

HEROLD H. (2004): Archaeological and scientific analyses of Early Medieval ceramics in Austria – A Case Study: Zillingtal (Burgendland, East-Austria). In: *U. Schüssler, E. Pernicka (Hrsg.): Archäometrie und Denkmalpflege 2004*, Kurzberichte der Jahrestagung in den Reiss-Engelhorn Museen, Mannheim, pp. 156-158.

The lack of adequate resolution in dating Avar ceramics seriously restricts the development of research on this period, thus the main goal of the investigations on the ceramics of Zillingtal was to establish a detailed chronological framework for the interpretation of these finds. On the basis of examinations of both the settlement- and cemetery ceramics two main types of ceramics could be separated: hand modelled pottery and pottery turned on a slow wheel. These two main groups can be very well distinguished macroscopically as well as in thin section, consequently the investigations concentrated on working out the means of dating within these groups. It was furthermore intended to identify the clay sources used, to characterise the technologically significant features of the investigated ceramic-fabrics and to develop ideas about the function of the investigated vessels. The combination of more scientific methods and the integration of experimental archaeology into the investigations represent a novel approach in the research of early medieval ceramics from the region. From among the results of the investigations on the ceramics of Zillingtal the aspect of chronology is summarised in this article.

HEROLD H. (2006): Quantitative micromorphological analysis of ceramic thin sections using scanning electron microscopy. In: *O. Hahn, H. Stege (Hrsg.): Archäometrie und Denkmalpflege 2006*, Kurzberichte der

Jahrestagung an der Staatlichen Akademie der Bildenden Künste, Stuttgart, pp. 144-146.

The problems of the quantification of microstructural data in polarising microscopy are well known: under crossed polars grains of the same mineral can have different colours and, also, grains of different minerals can show the same colour. This makes a digital quantitative micromorphological analysis of polarising microscope pictures almost impossible.

In order to solve this problem scanning electron microscopy was used. On a SEM image all particles are shown in different shades of grey according to the atomic weight of their constituents. Moreover it is possible to produce mappings of the distribution of chemical elements within the sample. The images obtained in the SEM are thus best suitable for a digital quantitative analysis and allow the recording of different features of grain size and shape, which can be used for a quantitative differentiation between groups of samples on a micromorphological basis.

The first results of these micromorphological measurements and analyses are presented here on the example of the so called "polished yellow ceramics" of the Carolingian Period (9th century AD) from the site of Zalavár (Hungary).

HEROLD H. (2007): The "polished yellow" ceramics of the Carolingian Period (9th century A.D.) Samples from Zalavár, South-West Hungary. In: Waksman, Y. ed., Archaeometric and Archaeological Approaches to Ceramics. Papers presented at EMAC '05, 8th European Meeting on Ancient Ceramics, Lyon 2005. *BAR International Series*, Oxford **1691** 137-144.

The ceramics analysed belong to the very distinct group of the so called "polished yellow" ceramics, which are the best-quality ceramics of the Early Medieval sites concerned. Similar "yellow ceramics" are known from the same period from different parts of Central- and Eastern-Europe, in a region ranging from today's Austria to Bulgaria. The primary goal of the investigations presented here is to find and characterise the groups of this special ceramic type in order to a) establish a chronological sequence within this ceramic-ware and b) get information about the standard and the framework of its production as well as about the changes of the production structures through time.

On samples from Zalavár there were petrographic, XRF, XRD and SEM analyses performed. On the basis of polarising microscopy four ceramic-groups could be identified: Three groups poor in carbonates with different size and proportion of non-plastic inclusions and one group rich in carbonates. Analyses in the SEM reinforce the separation of the four groups found by polarising microscopy. The XRD analyses suggest a wide rage of firing temperatures (ca. 650-950 ºC) for the investigated samples.

HEROLD H. (in press): *Die awarenzeitliche Siedlung und die gefäßkeramischen Funde des awarenzeitlichen Gräberfeldes von Zillingtal, Burgenland* (The Avar-Period settlement and the ceramic vessels of the Avar-Period cemetery of Zillingtal, Burgenland – in German) Monographien zur Frühgeschichte und Mittelalterarchäologie, Mainz, in press (258 pages, 93 figures, 220 plates, 3 maps).

This monograph summarises all archaeological and archaeometric investigations on the ceramic finds from the Early Medieval settlement and cemetery of Zillingtal (Burgenland, Austria). The structure of the monograph follows approximately the research process. It begins with a short summary of the history of the excavations in Zillingtal, followed by the first main chapter about the ceramic finds from the Avar Period. Here first the macroscopic groups of the ceramic finds from the settlement and the cemetery are described, afterwards the experiments and the archaeometric analyses are presented. Considerations about settlement- and funeral ceramics and about pottery production in Zilligtal round off this chapter. In the next two chapters the contribution of ceramics analysis results to the interpretation of the settlement and of the cemetery are discussed. Afterwards new information on the relative situation of settlements and cemeteries of the Avar period in and around Zillingtal is described. The last two chapters provide a comprehensive view of the research on settlements and ceramic finds of the Avar Khaganate. The appendix contains the catalogues and plates of the ceramic finds from the settlement and cemetery of Zillingtal.

HEROLD H. (in press): Archäometrische Keramikanalysen in Hallstatt. (Archaeometric analysis of ceramics from Hallstatt – in German) In: Anton Kern – Johann Reschreiter

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– Kerstin Kowarik (Hrsg.): Hallstatt und sein archäologisches Erbe. Wien.

Samples from ceramic vessels from the Early Iron Age cemetery at the salt mine of Hallstatt (Austria) were investigated with thin section analysis. The analyses showed that in the case of seven of the ten samples a local provenance is well possible. This result is surprising, since archaeological research has hitherto assumed that the population of Hallstatt was exclusively involved in mining salt and imported all other goods to the site. Three of the investigated samples are most probably not from local production. The provenance two of these samples could not be further specified. For one sample, on the basis of foraminifera contained, is a provenance west of Hallstatt, in the region of Gosau probable. The next step of the investigations concerning the ceramics of Hallstatt is the thin sectioning of local sediment samples and of further ceramic vessels from Hallstatt as well as from other sites from the same period in the vicinity of Hallstatt.

HEROLD H., PETSCHICK R. (2003): Herkunftsbestimmung frühmittelalterlicher Keramik und Rekonstruktion ihrer Brenntemperatur mittels Kombination von Röntgendiffraktionsanalyse, Tonprobennahme und Brennversuchen. (Provenance analysis of Early-Medieval ceramics and the reconstruction of their estimated firing temperature by a combination of X-ray diffraction analysis, clay-sampling and firing experiments – in German). *Berliner Beiträge zur Archäometrie*, Band **20/2003**, Berlin, pp. 31-47.

On the basis of XRD analyses of archaeological ceramics from the Early Medieval site of Zillingtal (Burgenland, East-Austria) and of clay samples collected at the site it was attempted to draw conclusions about the provenance of the raw materials and about the methods of ceramics production in Zillingtal. The analyses showed that a local provenance of the raw materials for ceramics production in Zillingtal is well possible. At certain points in the vicinity of the site sediments could be found which could not be processed to ceramics (they fell apart during firing); the reason for this is probably their dolomite content, which is considerably higher than that of the other samples collected. Most of the samples collected are, however, well suitable for producing ceramics and their mineralogical composition is also well compatible with that of the archaeological ceramics found in Zillingtal.

On the basis of the firing experiments the firing temperature of the archaeological ceramics can be reconstructed to have been above 650 °C; the firing process lasted probably over 2 hours.

HEROLD H., ULREICH H. (2005): Dünnschliffuntersuchungen prähistorischer Keramik von Hoyas del Castillo, Pajaroncillo (Cuenca), Spanien. (Thin section analysis of prehistoric ceramics from Hoyas del Castillo, Pajaroncillo (Cuenca), Spain – in German with summaries in English and Spanish). *Anzeiger der philosophisch-historischen Klasse 139*, Jahrgang 2004, Österreichische Akademie der Wissenschaften, Wien, pp. 85-99.

Samples of prehistoric ceramics found at the Site Hoyas del Castillo, Pajaroncillo (Cuenca) were analysed by petrographic thin section analysis. 15 of the analysed 16 samples consist of a very similar clay-matrix (with a low content of fine quartz, moderate amounts of an opaque phase and very few carbonates; proportion of non-plastic components 6-7 Vol%) to which different types of temper were added. There were five types of tempering practices detected: raw material type 1 with grog temper, raw material type 2 with large amounts of quartz temper, raw material type 3 with moderate amounts of quartz temper, raw material type 4 with large amounts of mixed quartz-, carbonate- and grog temper and raw material type 5 with carbonate temper. On the basis of the geological map of the surroundings of the site the local provenience of these five raw material types is well possible.

Sample 7 differs in many aspects from the rest of the analysed thin sections ("fat" clay, well sorted non-plastic components, a different type of void shape and structure). The vessel from which this sample originates was most probably imported to the site.

HOLLÓ, L., VERŐ, J. (1979): Geofizikai mérések a Magyarfalva-Kányaszurdok-i vaskohónál. (Geophysical measurements at the iron furnaces of Magyarfalva-Kányaszurdok). *Arrabona*, **21**, pp. 109-112. (In Hungarian). (from ARH I.).

HOLLÓ, L., VERŐ, J. (1984): Beszámoló a Magyarfalva-Kányaszurdok-i vaskohóknál és

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téglaégető kemencéknél végzett geofizikai mérések eredményéről. (Report on the results of geophysical measurements at the iron furnaces and brick kilns at Magyarfalva-Kányaszurdok). *Iparrégészet II.*, Veszprém, pp. 141-146. (In Hungarian).

The two similar reports describe geoelectric measurements of specific resistivity, with the result that low resistivity spots could be identified with slag accumulation, having about half the resistivity of a more humic environment. The remains of the Roman brick kilns caused an increase of about 50 to 80 per cent in the specific resistivity. (from ARH I.).

HORVÁTH, T; GHERDÁN, K., HERBICH, K., VASÁROS, ZS. (2007): Häuser der Badener Kultur am Fundort Balatonőszöd-Temetői Dűlő. *Acta Arch. Hung.,* **58**, Budapest, pp. 43–105.

A large settlement of the Baden culture was unearthed preceding the construction of the track of highway M7. At the Late Copper Age settlement the remains of four buildings (house foundations, daub fragments and miniature house models were uncovered from the classical phase of the culture. The buildings were over ground wood-structure houses plastered with daub and raised on posts above the waterlogged territory. They could have profane and sacral functions as well.

HORVATINCIC, N., OBELIC, B., SRDOC, D., DURMAN, A., BENKŐ, L., SLIEPCEVIC, A. (1990): Radiocarbon and TL dating of the Eneolithic site Vučedol in East Croatia, Yugoslavia. *PACT Journal*, **29**, p. 243.

Results show that Baden and Kostolac cultural layers extend from 3400 to 2900 cal BC, the Vučedol culture spans the period from 3000 to 2700 cal BC. (from ARH II.).

ILON, G., SABJÁN, T. (1989): XV. századi cserépkályhák Külsővatról. (Kachelöfen aus dem XV. Jahrhundert aus Külsővat). *Acta Musei Panensis, Pápai Múzeumi Értesítő*, **2**, pp. 77-140.

The archaeological reconstruction of oven tiles is combined with the analysis of archaeozoological and macrobotanical remains. (from ARH II.).

ILON, G., VARGA, I. (1994): Bauxit a kerámiában? (Bauxit in the spätbronzezeitlichen Keramik?). *VMMK*, **19/20**, pp. 133-140.

The role of bauxite is discussed in Late Bronze Age pottery manufacturing. (from ARH II.).

JEREM, E., BALLA, M., BALÁZS, L. (1998): Early Celtic stamped pottery in the Eastern Alpine area. Workshop activity and trade. *ARH* **II.** pp. 83-96.

Early Celtic stamped pottery from Sopron (northwestern Hungary) was analysed to identify a chemical fingerprint that could be used to establish time horizons and connections between kiln and contemporary settlement features.

JEREM, E., BIRÓ, K. T., eds (2002): Archaeometry 98. Proceedings of the 31st Symposium, Budapest, April 26-May 3. *BAR International Series*, Vols. I-II Oxford 1042, 1043.

Papers presented for the 31st International Symposium on Archaeometry, Budapest.

JÓZSA, S., SZAKMÁNY, Gy. (1987): Petrology. In T. Bezeczky ed.: Roman Amphorae from the Amber Route in Western Pannonia, *BAR International Series*, **386**, Oxford, pp. 103-124.

Investigations on thin sections of 81 amphora fragments were carried out by polarizing microscopy. The samples were collected from the Amber Route. The ratio of matrix, clasts and limonite were determined. The various clasts were identified and their percentages calculated. The data were documented in several tables.

The amphorae represented the following types and workshops: Dressel 2-4, Dressel 5, Dressel 6B (from various workshops, locality or stamps: C. Laecanius Bassus, Calvia Crispinilla, amphorae from Loron, amphorae with imperial stamps, amphorae without any stamps), Dressel 20.

The following clasts occured: Minerals – quartz, K-feldspars, plagioclase, micas (biotite, muscovite), opaque minerals, pyroxene (few), accessories (zoisite-clinozoisite, epidote, tourmaline, apatite, zircon, garnet, titanite). Rock fragments – dominant: quartzite, sparite, micrite, subordinate: shale, gneiss, mica-schist, phyllite and granite. Fossils – calcitic-, opalic- and quartzitic fossils.

The individual workshops (identified by the stamps) were grouped on the basis of the quality of various clasts and the ratio of clasts to the matrix and limonite. Brief petrographical features of all the amphora types studied were described. (from ARH II.).

JÓZSA, S., SAUER, R., SZAKMÁNY, Gy., WEISZBURG, T. (1994): Mineralogisch petrografische Untersuchungen. In: *T. Bezeczky (ed.): Amphorenfunde vom Magdalensberg und aus Pannonien*, Kärntner Museumsschriften 74. Archäologische Forschungen zu den Grabungen auf dem Magdalensberg 12, Klagenfurt, pp. 143-195 (with 12 tables containing 192 colour polarizing microscopic photos of the amphorae).

Petrographical and X-ray powder diffraction studies were carried out on about 180 pottery samples (stamped and not stamped amphora fragments) collected from Magdalensberg (Austria) and from other places (recently in Hungary, Slovenia, Croatia) of the Roman province Pannonia. The following types and workshops were represented among the amophorae studied: Dressel 6B (dominant type), Dressel 2-4, Dressel 5, Dressel 6A, Dressel 7-11, Portorecanati and Schörgendorfer 558. Both the clasts and the matrix (groundmass) of the pottery were characterized. The data were summarized in several tables.

The following clasts of amphorae were determined by polarizing microscope: Minerals – quartz, K-feldspars (orthoclase, sanidine and few microcline), plagioclase, micas (biotite, muscovite), chlorite, opaque minerals, pyroxene (few), amphibole (few), accessories (zircon, rutile, tourmaline, apatite, garnet, epidote, zoisite-clinozoisite, kyanite). Rock fragments – quartzite, chert, siliceous shale, sandstone, mudstone, shale, sparite, micrite, phyllite, mica-schist, granite, volcanite, volcanic glass. Fossils – calcitic- (foraminifera, shell fragments), opalic- (spicula) and quartzitic- (radiolaria) fossils.

The groundmass of the amphorae consisted of quartz, K-feldspar, plagioclase, micas, calcite, gehlenite, pyroxene, amphibole, gypsum, wairakite (determined by X-ray powder diffraction).

The analysis of the clasts of the stamped samples made it possible to give the common mineral and rock types for the different workshops (which information can be utilized while handling not stamped fragments). The mineral and rock types, characteristic for different geological environments, could be used for giving information about the geographic position of the workshops. The size and the shape of the clasts and the type and colour of the groundmass gave information about the ancient preparation and burning technology. (from ARH II.).

KALICZ, N., KREITER, A., KREITER, E., TOKAI, Z. M. (in press): A Neolitikum történeti és kronológiai kérdései Becsehely-Bükkaljai-dűlő lelőhelyen. (Historical and chronological questions of the Neolithic at Becsehely-Bükkaljai-dűlő (Hungary)). *MOMOS-Őskoros Kutatók IV. Összejövetele*, (In Hungarian).

By the means of microscopic and petrological analyses this paper explores the relationship between the Transdanubian Linear Pottery Culture (TLPC), Malo Korenovo (MK) and Sopot cultural groups through their ceramic technology. The analyses revealed that Sopot wares have different technological characteristics from the MK and TLPC wares. The MK sample, however, shows great similarities to the examined TLP ware in terms of technological practices. The chronological position of the MK is important in order to understand the Middle Neolithic and this study offers a better understanding of the cultural relationship between the MK and TLPC cultural groups.

KARDOS, J., KRISTON, L**.** (1980): Kerámiatárgyak röntgendiffrakciós vizsgálata. (X-ray analysis of ceramic objects). *Múzeumi Műtárgyvédelem*, **1980/7**, Budapest, pp. 36-47. (In Hungarian).

Samples taken from Iron Age and Middle Ages pottery as well as from potsherds from the period of the Great Migration were analysed by X-ray diffraction. Knowing the crystalline phase of the pottery the authors tried to determine the materials used by the potters, and the origin of these materials. They examined the changes of phases produced by the heating which could furnish information on the manufacturing conditions (firing temperature etc.). (from ARH I.).

KARDOS, J., KRISTON, L**.** (1984): A Sopron-Krautacker lelőhelyen feltárt kelta fazekas kemence anyagának vizsgálata röntgendiffrakciós elemzéssel. (Investigation of the material of a Celtic pottery kiln from Sopron-Krautacker dülő by X-ray). *Iparrégészet II*, Veszprém, pp. 107-110. (In Hungarian).

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Using X-ray diffraction analysis, crystalline phases were determined from samples taken from nine locations of the pottery kiln. It was found that the walls of the kiln were built from carbonate-free brown forest soil, while the grate and the flue tunnel are composed of the carbonate-rich level of the same type of soil in situ. Soil samples taken from the vicinity of the kilns were heated to different temperatures and the crystalline phases after cooling were analysed by X-ray diffraction. Through information on the crystalline phase of the pottery material, the firing temperature could be found. Analysis of pottery found in the kiln indicates that the firing was a reduction type and the potsherds were heated to about 600-700°C. (from ARH I.).

KARDOS, J., TRÄGER, T**.,** ZIMMER, K**.** (1983): A hevítés hatása régészeti kerámiatárgyak spektrográfiásan meghatározott nyomelemtartalmára. (The effect of firing on optical emission spectroscopic determination of trace elements in archaeological pottery). *Proc. 26th Hung. Conf. on Spectral Analysis*, Kecskemét, p. 97. (In Hungarian).

Provenance studies of pottery are based on reliable analytical data. A lot of factors influence the result of chemical analysis: pre- and post-depositional alterations, homogeneity, sampling, sample preparation, etc.

Firing is a crutial factor in the pre-depositional history of pottery. During firing the phase and elemental composition change considerably as a consequence of exothermic and endothermic reactions. solod state reactions rearrange the crystal structure, ferrous oxide transforms ferric oxide, and water vapour, carbon dioxide, sulphur dioxide and volatile elements evaporate, as functions of firing temperature and atmosphere. Some of the trace elements (cadmium and copper) can be mobilized easily at high temperature bacause of vitrification of the ceramic material.

Direct current arc excitation of clay samples heated at different temperatures (350-1000 °C) proved that the usually non-volatile trace elements (chromium, manganese, titanium, vanadium) evaporated to a greater extent, modifying the analytical results, if the ceramic matrix is in vitrified form. Samples to be analysed must be treated by heating at 800 °C for 2 hours to get a quasi-uniform condition diminishing the effect of the firing process. (from ARH I.).

KARDOS, J., ZIMMER, K**.,** KRISTON, L**.,** MOROZOVA, O**.,** TRÄGER, T**.,** JEREM, E**.** (1985): Scientific investigations of Sopron-Krautacker Iron Age workshop. *Archaeometry*, **27/1**, pp. 83-93.

The operation of a pottery workshop can be charactrrizid only incompletely by archaeological data, however a knowlegde of the raw material and of the manufacturing processes are integral parts of the overall picture. By using appropriate methods (X-ray diffraction, X-ray fluorescence spectroscopy and thermal analysis) and by taking advantage of the special features of the Sopron-Krautacker archaeological site (pottery kilns together with waste dumps and clay pits) some generalizations can be made. Clay with no or low calcium carbonate contents respectively, were used as a source of raw material by the Celtic potters although the utilization of clay with high carbonate content was also made possible by characteristics of the soil. The nearly carbonate-free upper layer of the local soil was formed by a leaching process.

The vessels were fired at 600-700°C. This temperature was confirmed by investigation of the kilns. The Celtic potters must have chosen the non-calcareous layer intentionally, because calcium oxide as a decomposition product can destroy vessels. Calcium oxide can combine with water vapour in the air to form calcium hydroxide. Since the volume of calcium hydroxide is greater than calcium oxide or calcium carbonate, this expansion can exert enough pressure to rupture the walls. The recarbonization process observed suggests a possibility for formation of secondary calcium carbonate, which may be the only source of secondary carbonate in the pottery.

The large quantity of bowls, flasks and cooking pots of generalized forms excavated at the site indicates mass production, showing a transition from home craft into industrial activity. This fact, however, assumes the application of a safe, well controllable production with little waste. (from ARH I.).

KASZTOVSZKY, ZS., SAJO-BOHUS, L. (2003): Kolumbus előtti venezuelai kerámialeletek vizsgálata prompt gamma aktivációs analízissel. (in Hungarian) *Fizikai Szemle*, pp. 94-96.

140 km from the Venezuelan coast, 46 koral islands constitute the group of islands Los Roques. Between 1981 and 1996, 25 archaeological settlements were excavated here. The finds comprised some 400

anthropomorphic ceramic figurines and their fragments. On the basis of stylistic criteria, the figurines resemble much to Valencian and Ocumaran type statuettes from the Northern regions of Venezuela. The figurines were investigated by PGAA to study the bulk composition and identify possible sources of raw material.

KASZTOVSZKY ZS., ANTCZAK, M. M., ANTCZAK, A., MILLAN, B., BERMÚDEZ, J., SAJO-BOHUS, L. (2004): Provenance study of Amerindian pottery figurines with prompt gamma activation analysis, *Nukleonika*, **49, (3),** pp. 107-113.

Archaeologists of the Simón Bolívar University initiated a research project aimed to perform a provenance study of pre-Hispanic pottery figurines. Almost five hundred figurines has been recovered altogether in four sites of the Archipelago. Forty fragments of figurines from two archaeological sites were investigated by PGAA, concentrations of major- and some trace components were determined. Among others, K_2O, Cl and Cr were found to be the most significant to distinguish between samples from Lake Valencia Basin (mainland) and from Los Roques Islands. By relating the island figurines to their stylistical and chemical counterparts from the mainland we wish to provide chronological information to hundreds of mainland figurines.

KISS, V. (1996): Megfigyelések a dunántúli mészbetétes kerámia kultúrája edénydíszítési technikájáról. (Observations on the ceramic-decoration techniques of the transdanubian incrusted ware culture). *Acta Musei Papensis, Pápai Múzeumi Értesítő,* **6**, pp. 65-76. (from ARH II.).

KREITER, A. (2005): Preliminary Report of Middle Bronze Age Ceramic Analyses from Százhalombatta. In: *The Emergence of European Communities: SAX Report 2*, pp. 187-194, (in English).

This paper, by employing macroscopic and ceramic petrological analyses investigates the ceramic technology of the Nagyrév and Vatya periods at the Bronze Age tell settlement of Százhalombatta, Hungary. The results suggest that the ceramic technology of the Nagyrév and Vatya periods are not directed by evolutionary mechanism and the type and amount of tempering material were not influenced by functional limitations. While artisans modified the properties of clay it seems that these alterations and the temper added are the result of choices made by artisans between equally viable options.

KREITER, A. (2006): Kerámia technológiai vizsgálatok a Halomsíros-kultúra Esztergályhorváti-alsóbárándpusztai településéről: hagyomány és identitás. (Technological examination of Tumulus culture pottery from Esztergályhorváti-Alsóbárándpuszta (Hungary): tradition and identity). *Zalai Múzeum*, **15**, pp. 149-170, (in Hungarian).

This paper investigates the relationship between the ceramic technological tradtion of the Tumulus culture and other contemporary Bronze Age communities. By the means of microscopic and ceramic petrological examination the paper considers the functional expedience of quartz and limestone tempering. The utilisation of these tempering materials weakend the end products and it is argued that functional requirements may not give a complete explanation of these practices. This paper highlights the relationship between manufacturing sequences and technological tradition and argues that the choice of temper may have been used to express the identity of the potters and their community.

KREITER, A. (2007): Technological choices and material meanings in Early and Middle Bronze Age Hungary: understanding the active role of material culture through ceramic analysis. *BAR International Series*, Oxford, Archaeopress. **1604**

This study examines the relationship between technology and social organisation through Early and Middle Bronze Hungary. Through the concept of technological style it is argued that Bronze Age social relations were maintained through material culture production. Ceramic technology and shared technological choices can be viewed as a process that binds people together. Potters, and consumers, are seen to have a shared understanding of ceramic technological practices and how a culturally accepted vessel should be made. This approach calls into question the spatial boundedness of archaeological cultures and major historical processes such as migration, diffusion and

acculturation, traditional to Hungarian approaches.

KREITER, A. (in press): Bronzkori Kerámia Technológiai Vizsgálata Százhalombatta-Földvárról. (Examination of Bronze Age Ceramic Technology from Százhalombatta-Földvár). *MOMOS-Őskoros Kutatók IV. Összejövetele*, (in Hungarian).

This paper, by employing microscopic and ceramic petrological analyses establishes a strong relationship between the Nagyrév and Vatya periods at Százhalombatta (Hungary) in terms of technological practices. The strength of tradition depends on the reproduction of people's social and technical knowledge through time and it seems that Nagyrév and Vatya potters had similar conceptions of how technological tradition should be maintained. This implies common social networks and common perceptions of the reproduction of material culture. The technological similarities between the Nagyrév and Vatya at Százhalombatta indicate a common cultural tradition.

KREITER, A. (in press): Kerámia technológiai tradíció és az idő koncepciója a bronzkorban. (Ceramic technological tradition and the concept of time in the Bronze Age). *Ősrégészeti Levelek - Prehistoric Newsletters*, (in Hungarian).

This paper investigates the relationship between ceramic technology and social organisation through the Early and Middle Bronze Age in Hungary. By the means of microscopic and petrological examination the paper focuses on the use of grog temper in pottery making. It is considered that grog was an important means of conveying continuity in tradition and shows a cyclical conception of time. The results show that Early and Middle Bronze Age potters had similar conceptions of how technological tradition should be maintained, and how grog should be used. This suggests common social networks and perceptions of the reproduction of material culture.

KREITER, A., BAJNÓCZI, B., SIPOS, P., SZAKMÁNY, GY., TÓTH, M. (2007): Archaeometric examination of Early and Middle Bronze Age ceramics from Százhalombatta-Földvár, Hungary. *Archeometriai Műhely* (electronic periodical: http://www.ace.hu/am/index.html), (in English).

This paper examines the technology of Bronze Age ceramics from a tell settlement at Százhalombatta (Hungary) by using polarising and cathodoluminescence microscopy, XRD, and XRF analyses. Potential clay samples around the tell were also examined by the same techniques. Results suggest that potters used locally available clays and even the most distinct vessels in terms of decoration seem to be locally made. In spite of the similarities in clay compositions, however, there is a clear distinction between how potters manipulated their clay and temper even within a similar vessel type. This practice resulted in the existence of intrasite technological traditions.

KREITER, A., SOFAER, J., BUDDEN, S. (2005): Analysis of Early and Middle Bronze Age Storage Vessel Building Techniques from Hungary. *Ősrégészeti Levelek*, **2004/6**, pp. 85-91, (in English).

This paper discusses the techniques used to build storage vessels in the Early and Middle Bronze Age Nagyrév, Vatya, Kisapostag, Encrusted Pottery, Ottomány, Gyulavarsánd, Füzesabony and Tumulus ceramic traditions. In all cases, slab building was identified as an important method of construction, although techniques involving paddle and anvil, and coil construction were also recognised.

KRISTON, L. (1987): Adatok a soproni „vörös sánc" kiégetésének rekonstruálásához (Theoretical reconstruction of the burning of the Sopron „red mound"). *Soproni Szemle*, **2/1987, XII.,** pp. 141-146. (In Hungarian).

On the basis of data obtained by X-ray diffraction investigation of samples taken from the different parts of the so called red mound an attempt was made to reconstruct the burning out process of the huge earth work. According to the results the earthwork was subjected to relatively uniform heating (700-800°C to 450-500°C in the different sections). The burning out of the mound could not have occured by means of a direct process. (from ARH I.).

MANGE, M.A., BEZECZKY, T. (2006): Petrography and Provenance of Laecanius Amphorae from Istria, Northern Adriatic Region, Croatia. *Geoarchaeology: An International Journal*, **(2006) 21, No. 5,** pp. 429-460.

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Amphorae sherds from the Laecanius workshop of Roman Istria (10-5 BC and 78 AD), Croatia, were studied by integrating archaeological and geological techniques. Fabric analysis allowed the grouping of the sherds into nine fabric groups. Thin section petrography revealed that quartz is the dominant clastic component while carbonate is common as temper; XRD provided information on firing temperatures that ranged between 750-900° C. The sherds contain diverse heavy mineral suites. Garnet/epidote ratios and diagnostic species (pyroxene, hornblende) showed systematic variations which coincided with similar variations in fabric characteristics. Amphorae produced in other workshops were identified by their differing heavy mineral signatures. A comparative heavy mineral analysis of terra rossa samples indicated that terra rossa was the major source for the paste. Fresh Adriatic sponge spicules in the majority of Laecanius sherds and the temper-derived, generally immature heavy mineral assemblages suggest that sandy deposits from the Adriatic were used for the clastic temper.

PATTANTYÚS, Á.M. (1986): Geophysical results in archaeology in Hungary. *Geophysics*, **51/3**, pp. 561-567.

Several archaeological sites containing different artifacts were investigated by magnetic and geoelectric measurements. Kilns of medieval semisubterranean houses, ruins of a Roman brick building, and pits of a Copper Age settlement were discovered by magnetic methods. The ground plan of a Roman fortress was determined by resistivity measurements at a location where excavation was impossible because of the high groundwater level.

Resistivity measurements made of a Roman homestead to determine the location of a building are discussed in detail. By correlating characteristic maxima of filtered resistivity data, the placement and orientation of walls could be determined. From the measurements, the position and extent of a group of buildings were defined.

Prehistoric mining trenches can be located on the basis of anomalously low resistivities. We determined the exact location of a 50 000 year old flint mine on the outskirts of Budapest by geoelectric measurements and defined the location of the excavation on the basis of geophysical measurements. A three-dimensional picture constructed from apparent resistivities associated with different penetration depths agrees fairly well with the shape of the ancient mine trenches excavated later. (from ARH I.).

PINTÉR, F. (2005): Az izotópgeokémia alkalmazása az archeometriai kerámiavizsgálatokban. *Archeometriai Műhely*, **2**, pp. 52-56.

Radiogenic isotope geochemistry is a widely used analytical method among geochemical analyses. Radiogenic isotopes are mostly used for radiogenic dating of minerals and rocks, they can also be used as tracers (e.g. $^{87}Sr/^{86}Sr$, $^{143}Nd/^{144}Nd$, etc.) in characterization of geological regimes, rocks, and areas.

The radiogenic isotopes can also be successfully applied in the research of siliciclastic sediments. These mostly clayey sediments, which were used as raw materials of the pottery production, also bear the radiogenic isotope geochemical properties of the rocks of an orogenic region from which they derived due to alteration and sedimentation processes. Therefore radiogenic isotope ratios of the ceramics can provide valuable information about the origin of raw materials, and thus directly about the provenance of the artefacts.

PINTÉR, F., SATIR, M. (2005): Preliminary results on provenance analyses on Early Iron Age „Knobbed Ware“ from Troia, Thrace and the Balkans. In. *Prudencio et al., (eds.): Trabaljos de Arqueologia Instituto Portugues de Arqueologia*, Lisboa, 42, pp. 177-184.

The end of the Late Bronze Age and the beginning of the Early Iron Age in Troia is marked by a sequence of destruction and reconstruction horizons. In the settlement phase Troia VIIb2 (ca. 1100-1000 B.C.) new vessel forms of hand-made pottery with incised and knobbed decoration appear. The same vessel forms with similar decoration can be found in several archaeological localities in Thrace and the Balkans. The primary question in investigating the Knobbed Ware of Troia and the Balkans is whether there is a possible common origin of the pottery from different regions.

To answer this question several pottery and geological samples have been colleted from Troia and from archaeological sites in South-east Bulgaria and investigated petrographically and geochemically (XRF, Radiogene Isotope Analysis). On the basis of petrographical (modal) measurements the sherds have been grouped into eight groups

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and several subgroups. Further X-ray fluorescence analysis has been carried out in order to clear the grouping. Based on these data most potteries have good overlap with chemical patterns of the local sediments, so they seem to be locally produced. This observation is in accordance with archaeological theories concerning distribution of this type of pottery. The sherds which could not be definitely grouped with the above mentioned methods have been analysed with radiogene isotopes. Data have been compared to radiogene isotope values of sediments in Bulgaria, Thrace and Troia, and locally produced ceramics in Troia. Based on the results most potteries seem to be locally produced. This observation is in accordance with archaeological theories concerning distribution of this type of pottery.

PINTÉR, F., SATIR, M. (2006): Scherben unter dem Mikroskop - Archäometrische Keramikanalysen in Troia. In: *Korfmann, M. (ed.) "Troia - Archäologie eines Siedlungshügels und seiner Landschaft"*, Mainz, pp. 343-348.

Applied sciences for ceramic analysis in Troia have been used for more than sixty years. This paper presents the main objectives of archaeometric ceramic analyses and gives a short summary on the pottery analyses carried out on Troian archaeological ceramics in the last six decades. Since 1942, when the first petrographic investigation was done on Troian sherds, a great number of projects have been dealt with various questions concerning mainly the origin of different pottery groups. Some of these investigations, such as the first use of radiogenic isotopes in the provenance of archaeological pottery or the interpretation of chemical data in function of the mineralogical composition of the materials, have had a great importance in the methodological development of ceramic analyses. The large number of results and new data also reflect the effective cooperation of archaeologists and natural scientists.

SAJO-BOHUS, L., M. M., ANTCZAK, GRAVES, E. D., ANTCZAK, A., BERMÚDEZ, J., KASZTOVSZKY, ZS., POIRIER, T., SIMONITS, A. (2005): Incipient Archaeometry in Venezuela: Provenance Study of Pre-Hispanic Pottery Figurines. *J. Radioanal. Nucl. Chem.*, **265, (2),** pp. 247-256.

Application of different analytical techniques contributed with new results to the interpretation and the provenance study of Venezuelan figurines dating from the 12th and 15th centuries. Elements in bulk samples, powdered samples of figurines and soil were determined using Total Reflection X-ray fluorescence (TXRF), Instrumental Neutron Activation Analysis (INAA) and Prompt Gamma Activation Analysis (PGAA). Results and ceramics macroscopic observations indicate that average elemental composition of the figurines from the mainland significantly differ from those encountered on the Caribbean islands. The multidisciplinary experience de facto formed provided data for provenance study of pre-Hispanic pottery figurines.

SAJO-BOHUS, L., ANTCZAK, M. M., KASZTOVSZKY, ZS., GREAVES, E. D., ANTCZAK, A., SIMONITS, A., PALACIOS, D., MILLAN, B. (2006): Neutron Activation Analysis of Pre-Columbian Pottery in Venezuela. *Journal of Physics: Conference Series*, **41**, pp. 408-416.

Pottery figurines were analysed by neutron activation analysis (INAA and PGAA) at the Budapest Research Reactor, since they are convenient and reliable techniques. In order to classify pottery fragments and figurines, characteristic element components were determined. Several mass ratios were calculated for significant classification of the object of two origins. Results shed light on the origin of pottery figurines and may identify specific areas of production and migration patterns in the Caribbean region.

STARNINI, E., SZAKMÁNY, GY. (in press): Studio archeometrico comparativo di manufatti non vascolari in argilla cotta e di contenitori ceramici del Neolitico antico ungherese. In: *Atti della IX Giornata di Archeometria della Ceramica*, dal tema: Materiali "argillosi" non vascolari: un'occasione in più per l'archeologia, Torre di Pordenone, 18-19 aprile 2005.

The paper presents the preliminary results of an archaeometric study of potsherds and non-vessel fired clay artefacts, such as the so-called net-weights, loom-weights and plaster fragments of the Early Neolithic Körös Culture, combined with the study of soil samples collected from the respective Neolithic sites. The aim of the study was to better characterize the pottery production and to compare it to the local raw material sources. It is in fact supposed that the raw material for

plastering the structures of the settlements was collected from sources located for logistic reasons in the very proximity of the sites. The analyses of these samples represent the very first archaeometric study for this Culture in Hungary. The methods of investigation comprise the petrographic study with the polarizing microscope of thin sections of all samples, combined with geo-chemical (XRF, NAA) and SEM-EDS analyses.

STARNINI, E., SZAKMÁNY, GY., MADELLA, M. (2007): Archaeometry of the first pottery production in the Carpathian Basin: results from two years of research. In: *Atti del IV Congresso Nazionale di Archeometria,* Scienza e Beni Culturali, Pisa – 1-3 febbraio 2006.

The paper and its abstract illustrate the preliminary results of an archaeometric study on the first pottery production of the earliest farmers of the Carpathian Basin. The ceramic samples are from the Early Neolithic Körös Culture, dating to the beginning of the VII millennium BP. The studied samples comprise both potsherds, soil samples from the sites and non-vessel fired clay artefacts, such as net-weights, loom-weights and plaster fragments. These latter were studied with the aim of better characterising the composition of the local raw material and to compare it to that of the pottery production. The method of investigation includes the petrographic study with a polarizing microscope of thin sections, combined with XRD, XRF, NAA and SEM-EDS analyses. The study showed the intentional use of chaff as organic temper, inferred both from the presence of characteristic imprints in the paste and of typical phytoliths recognized in some thin sections.

SZAKMÁNY, GY. (1996): Petrographical investigation in thin section of some potsherds. In: *Makkay, J., Starnini, E., Tulok, M. (eds.): Excavations at Bicske-Galagonyás (part III). The Notenkopf and Sopot-Bicske cultural phases.* Società per la Preistoria e Protostoria della Regione Friuli-Venezia Giulia, Quaderno 6. Trieste, pp. 143-150.

The paper presents the results of an archaeometric study of ceramic samples of the Sopot-Bicske cultural phase of the Neolithic site of Bicske Galagonyás (Transdanubia, Hungary). The samples comprise a few potsherds that were studied with the aim to characterize their manufacturing technology and provenance. The methods of investigation comprise a petrographic study of thin sections of the samples with a polarizing microscope. The fabric of the ceramics is hiatal, and the non-plastic components are mainly monoquartz (magmatic and metamorphic origin), polyquartz, some feldspar (plagioclase and K-feldspar), muscovite, biotite opaque minerals and different amounts of accessories. There is quite a lot of micritic limestone with siliceous sponge spiculae, however, spiculae occur as individual constituents in great amount. Moreover there are some grog and/or ARF. The raw materials are supposed to derive from the weathered lower Jurassic Isztimer Limestone Formation, which contains quite a lot of sponge spiculae.

SZAKMÁNY, GY. (1998): Insight into the manufacturing technology and the workshops: evidence from petrographic study of ancient ceramics. *Archaeometrical Research in Hungary II.*, pp. 77-83.

The paper deals with the summarised results of a polarising microscopic study of Neolithic and Roman age ceramics. The review of the most common non-plastic components of ceramics (monoquartz, poliquartz, feldspars, micas, opaque minerals, accessories, carbonate, other sedimentary, magmatic and metamorphic rock fragments and finaly fossils), further provides a short summary about the structural and textural charactersitcis of the ceramics (description of groundmass, grain size, roundness of the clasts, porosity etc), which are essential for an adequate description and interpretation of an ancient ceramics.

SZAKMÁNY, GY. (2001): Felsővadász-Várdomb neolitikus és bronzkori kerámiatípusainak petrográfiai vizsgálata. *Herman Ottó Múzeum Évkönyve,* Miskolc, **XL.**, pp. 107-125.

In this paper six representative pottery samples of coarse and fine wares were studied in thin sections by a petrographic microscope from Felsővadász-Várdomb. Four sherds represent the Middle Neolithic Bükk Culture and two samples belong to Bronze Age coarse wares with broomed decoration. The textural-structural characteristics of the sherds were determined and detailed descriptions of the non-plastic inclusion of the ceramics were given. The most widespread Neolithic coarse pottery has a hiatal fabric and predominantly consists of phyllite and connected quartzite temper of rock types from the Szendrő Phyllite Formation. Another Neolithic coarse pottery

consists of ARF and grog, and only small amounts of phyllite clasts. The raw material of this coarse vessel originates from different (uppermost and/or lowermost) parts of a creek valley. The fine ware Bükk ceramics have significantly finer grained clasts than the coarse wares with well prepared raw material. Among the non-plastic clasts there are K-feldspar, granitoide and grog, and one sample also shows a micritic limestone. The raw materials of Bronze age ceramics contain a lot of poliquartz and micritic limestone, and their components are similar to some of the Neolithic sherds. Moreover, these non-plastic inclusions were added to the raw materials of the ceramics as temper.

SZAKMÁNY, GY., GHERDÁN, K., STARNINI, E. (2004): Kora neolitikus kerámiakészítés Magyarországon: a Körös és a Starčevo kultúra kerámiáinak összehasonlító archeometriai vizsgálata, *Archeometriai Műhely* (electronical periodical: http://www.ace.hu/am/index.html), **2004/1**. pp. 28-31. (in Hungarian)

Starčevo culture represents the north-westernmost aspect of the large Early Neolithic archaeological complex of the Balkans, which comprises towards the north-east the Körös culture and towards east the Criş culture. The characteristic pottery of the period is homogenous in form and macroscopic features over a wide area, suggesting a high degree of cultural contact and transmission of technological skills.

Both Körös and Starčevo pottery products have a fine grained serial fabric with a porous texture containing vegetal tempering material, probably chaff. In some samples rounded, pebble-like, almost opaque inclusions can be found. Petrography of the ceramics and geochemistry of the nodules suggest that argillaceous silt or silty clay was used as raw material. All samples have sandwich-like structure and compositional differences between the core and the margin suggest low maximum firing temperatures (max 700–750ºC), short soaking time and high heating rate.

SZAKMÁNY, GY., GHERDÁN, K., STARNINI E. (2006): Early Neolithic pottery production in Hungary: a comparative archaeometrical study of Körös and Starčevo ceramics. In: *Proceedings of the 34th International Symposium on Archaeometry*, Saragozza May 2004, pp. 549-554.

The paper presents the preliminary comparative study of the pottery productions of two Early Neolithic cultural groups (Körös and Starčevo) of the Carpathian Basin, using petrologic and geochemical methods. In both cultures ceramics have similar macroscopic features and mineralogical and geochemical composition. The presence in the paste of iron-rich nodules and their geochemical composition suggest that argillaceous silt or silty clay already subjected to pedogenesis was tempered with vegetal material and used as raw material in pottery manufacturing. X-ray powder diffraction analyses of the paste showed that vessels were fired at low maximum temperatures of 700–750ºC, with high heating rates and low soaking times.

Data available so far confirm the great homogeneity, already noticed at stylistic level, of the ceramic production (raw material, firing) of the early Neolithic in Hungary, the Carpathian Basin and the Balkans throughout a long period, most probably indicating cultural transmission within groups belonging to a traditionally structured, technologically stable society.

SZAKMÁNY, GY., KUSTÁR, R. (2000): Untersuchung von Keramikproben aus dem spätbronzezeitlichen Hügel von Isztimér–Csőszpuszta. *Alba Regia, Annales Musei Stephani Regis*, **29**, pp. 55-60.

This paper provides the results of a petrographic and XRD analyses of seven representative Late Bronze Age (Tumulus culture) ceramics with different tipological characteristics. The non-plastic clasts are predominantly mono- and polycrystalline quartz, in some cases chert, feldspars (K-feldspars in higher amount than plagioclase), muscovite, accessories (tourmaline, zircon, apatite, rutile, titanite and opaque minerals), and some samples also contain primary micritic carbonate fragments (crushed limestone clasts). All samples contain more or less grog and/or argillaceous rock fragments (ARF). The examined vessels were tempered with grog and coarse grained sand, and in some cases crushed limestone. On the basis of XRD studies there are two compositional groups of ceramics, moreover secondary clay minerals could also be determined. The firing temperature of the vessels was low, presumably around 600^{o}C.

SZAKMÁNY, GY., STARNINI, E., RAUCSIK, B. (2005): A preliminary archaeometric

investigation of Early-Neolithic pottery from the Körös Culture (S. Hungary). In: Kars, H, Burke, E. (eds.): Proceedings of the 33rd International Symposium on Archaeometry, 22-26 April 2002, Amsterdam, *Geological and Bioarchaeological Studies*, **3**, pp. 269-272.

The article illustrates the preliminary results of an archaeometric study on the first pottery production of the earliest farmers of the Carpathian Basin. The ceramic samples are from different Hungarian sites of the Early Neolithic, belonging to the Körös Culture. The studied samples were selected with the aim of better characterising the pottery production of this Neolithic Culture which occupied a large part of the Carpathian Basin. The method of investigation includes the petrographic study with a polarizing microscope of thin sections, combined with mineralogical (XRD), and SEM-EDS analyses. the incrustations too. We succeeded to group the pottery from different regions and periods by the composition of the ornament. It was concluded that the elemental composition of the ornament may be characteristic to the provenance of the pottery.

In case of samples from Vörs-Máriaasszonysziget the presence of a kind of grit in the incrustations with high calcium and phosphorus content was established. The material of the grit is presumably bone. Samples from other archaeological localities can be described by incrustations with different compositions. Incrustations in the samples from Balatonfűző are presumably composed of limestone ($CaCO_3$) from Baradla cave (Aggtelek) probably of white clay paste (kaolinite). It was also concluded that the red color of the ornaments of some sample from Baradla cave is caused by hematite.

SZIGETI, J., SZILÁGYI, V. (in press): A Halimba-Cseres X-XII. századi temető kerámiaanyaga. (The ceramic assemblage of the 10th-12th century cemetery of Halimba-Cseres). *Sötét idők falvai – 8-11. századi települések a Kárpát-medencében Conference*, Szilágyi, K. (ed.), Debrecen, (in Hungarian).

The 10th-12th century cemetery of Halimba-Cseres (Western Hungary, Bakony Mountains) contains graves with ceramic supplements. The detailed archaeological re-elaboration of the site and the archaeometric (microscopic petrographic) investigation of a part of this ceramic assemblage proved that the former classification of the objects and the chronological history of the cemetery requires some modification and correction. In contrast with the former conception about the local pottery making technology the sand tempering method is not the only way of preparation of the raw material because we could identify non-tempered samples too. In some cases a thin slip could be observed on the surface of the ceramics.

SZÍKI, G. Á., T. BIRÓ, K., UZONYI, I., DOBOS, E., KISS, Á. Z. (2003): Investigation of incrusted pottery found in the territory of Hungary by micro-PIXE method. *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*, **210**, pp. 478-X.

Incrusted pottery samples from the territory of Hungary were analyzed by micro-PIXE technique. Measurements were executed on the front and back side of the samples and inside

SZILÁGYI, V. (in press): Honfoglalás- és Árpád-kori kerámiák anyagvizsgálata Északkelet-Magyarországról I. (Borsod, Karos). (Archaeometric investigation of ceramics of the Period of the Hungarian Conquest and the Árpád Era from North-East Hungary – 1st Part (Borsod, Karos)). *Sötét idők falvai – 8-11. századi települések a Kárpát-medencében Conference*, Szilágyi K. (ed.), Debrecen, (in Hungarian).

This study deals with the archaeometric investigation of the ceramic assemblage of a 10th century settlement, Borsod (North-East Hungary). To get a wider picture of the pottery making technology of this epoch it was make a comparison with some ceramic finds of Karos which is a settlement of the same age and the same geographical area. The analytical procedure was based on microscopic petrographic and instrumental mineralogical and chemical investigations. To sum up, it can be stated that the ceramic manufacture of the two 10th century settlements (Borsod és Karos) was on a similar technological level and both handicrafts could represent the average state of this era. If it is true that the potter's craft of the 10th century could be characterized by the direct use of local alluvial sediments, it is a rare case when they applied tempering or levigation of the clay. The firing procedure was fulfilled on a lower temperature and uncontrolled atmosphere. It is probable that the isolated potter's craft of Borsod produced not only the lower quality cooking pots but the much higher quality ceramics too. There were no imported vessels in the investigated sample collection. Special pieces of the Borsod

ceramic assemblage which show shape and surface deformation were determined as victims of the fired which destroyed the village.

SZILÁGYI, V. (in press): Honfoglalás- és Árpád-kori kerámiák anyagvizsgálata Északkelet-Magyarországról II. (Mező-keresztes, Hejőkürt, Felsőzsolca, Karos). (Archaeometric investigation of ceramics of the Period of the Hungarian Conquest and the Árpád Era from North-East Hungary – 2nd Part (Mezőkeresztes, Hejőkürt, Felsőzsolca, Karos)). *Sötét idők falvai – 8-11. századi települések a Kárpát-medencében Conference*, Szilágyi K. (ed.), Debrecen, (in Hungarian).

This study deals with the archaeometric research of ceramic finds of four 10th century settlement from north-east Hungary (Mezőkeresztes-Lucernás, Hejőkürt-Cifrahát, Felsőzsolca-Várdomb and Karos-Tobolyka). We used microscopic petrographic observation during the investigation. To sum up, we can state that the investigated pottery material of all the four sites was manufactured dominantly of local alluvial sediments and without any preparation (no tempering, no levigation of clay). There could not be identified significant differences between the cooking pots and the higher quality fine wares. The only exception was the group of some light coloured fragments (from Felsőzsolca-Várhegy and Karos-Tobolyka) which are similar to the so called "white ceramic of Buda" because their plastic raw material could be derived from a non-local, not identified source. These exceptional ceramics can be imported wares in the territory. During the manufacturing potters could apply a relatively low firing temperature (<750°C) and the atmosphere of the firing place was uncontrolled (oxidative-reductive) which character suggests a lower technological level of firing in this epoch.

SZILÁGYI, V., GYARMATI, J., SZAKMÁNY, Gy., TÓTH M. (in press): Preliminary Comparative Archaeometric Results on Inka and Colonial Ceramics from Paria (Oruro, Bolivia). In: Waksman, Y. ed., Archaeometric and Archaeological Approaches to Ceramics. Papers presented at EMAC '05, 8th European Meeting on Ancient Ceramics, Lyon 2005. *BAR International Series*, Oxford **1691**

This study deals with the comparison of Inka Imperial and the Inka provincial administrative centre of Paria (Western Bolivia) because in the archaeological site, archaeological evidence of the two consecutive cultures, the Inka and the conquering Spanish, have been found. According to historical sources, Paria was the very first Spanish settlement in present Bolivia and was founded at the Inka administrative centre in 1535. Excavations there in recent years have recovered Colonial ceramics of the 16th and 17th centuries in large quantities besides Inka pots. Some forms of the Colonial pottery show a similarity in appearance to the Inka ceramics. The results of the archaeometric (microscopic petrographic, XRPD) investigation suggest that the raw material usage in pottery making technology did not change to a significant extent in Paria in the transition of the Inka Period to the Colonial Period. The most relevant difference between the subsequent historical periods is the disappearance of local ceramics at the end of the Inka Period, and the appearance of some new raw materials in the Colonial Period. In contrast to the raw material usage, the firing technology appears to have changed to a significant degree: the result of the technological development in the transitional Inka to Colonial Period was a higher firing temperature, which may be related to the Spanish pottery making traditions coming into the area. However, these results, obtained on a small sample, may not be representative of the majority of the archaeological ceramics, and need to be confirmed on the basis of a larger representative sampling.

SZILÁGYI, V., SZAKMÁNY, Gy., GYARMATI, J. (2005): Inka kori kerámiák petrográfiai vizsgálatának előzetes eredményei (Paria, Bolívia). (Preliminary results of petrographic investigation of Inka period ceramics (Paria, Bolivia)). *Archeometriai Műhely* (electronic periodical: http://www.ace.hu/am/index.html), **2005/2**, pp. 42-47, (in Hungarian).

The subject of our research is the archaeometrical-petrographic investigation of pot sherds excavated in a provincial centre of the Inka Empire (Paria) in the recent Bolivia. Preliminary observations were carried out on the collection of sporadic surface ceramic finds. The gained results can furnish basic data to further systematic investigations of the excavated finds. The authors' main goal is to identify the used raw materials and to characterize ceramic making technology (raw material preparation, firing). The basic method of pottery investigation is the microscopic petrographic observation. The result of this examination in general was that the Inka ceramics of Paria are well-fired ones (red in the whole cross-section) with hiatal

fabric and medial porosity. Main grain size is diverse (50—1000 μm) and fabric is often oriented. Classification of the sherds was based on the mineralogical composition of the non plastic inclusions. Three main groups could be distinguished (1 – mineral fragment, 2 – volcanoclastic rock fragment, 3 – siltstone rock fragment dominated types). The raw material of these potteries could derive from different deposits of the same geological setting. There is only one sherd that can be interpreted as a fragment of imported product.

SZILÁGYI, V., SZAKMÁNY, Gy., WOLF, M., WEISZBURG, T. (2004): Az edelényi, 10. századi település kerámia leletegyüttesének archeometriai vizsgálata. (Archaeometric investigation of ceramic finds of the 10th century settlement of Edelény). *Archeometriai Műhely* (electronic periodical: http://www.ace.hu/am/index.html), **2004/1**, pp. 34-39, (in Hungarian).

SZILÁGYI, V., SZAKMÁNY, Gy., WOLF, M. (2006): Az edelényi, X. századi település kerámia leletegyüttesének archeometriai vizsgálata. (Archaeometric investigation of ceramic finds of the 10th century settlement of Edelény). In: *Holló, Sz.A., Szulovszky, J. (eds.): Az agyagművesség évezredei a Kárpát-medencében.* Budapest-Veszprém, pp. 59-64, (in Hungarian).

These studies deal with the archaeometric investigation of ceramic finds of a 10th century (period of the Hungarian Conquest) archaeological settlement, Edelény, north-east Hungary. The majority of the samples are stubby cooking pots, accompanied by few ceramics that have characteristics similar to that of a former eastern culture, Saltovo. The analytical program was based on macroscopic and thin section petrography, accompanied by X-ray powder diffraction and X-ray fluorescence analysis of the pottery samples. Besides the pottery assemblage, a natural, clay rich sediment, collected in the vicinity of the excavation, was also examined with the same methods. There could be distinguished three groups of pottery based on composition of the non-plastics. Comparison of the pottery assemblage and the geology of the area (gathering ground of river Bódva) suggests that the potteries were made of local raw material (river clay and sand). In most cases the use of temper can not be proved, although there are few samples that show signs of tempering. Import ceramics were not identified. Technological investigations show that ceramics were fired at relatively low maximum temperatures (<750˚C) in an uncontrolled atmosphere.

TAUBALD, H., T. BIRÓ, K. (2005): "Archaeometrical analysis of Neolithic pottery and comparison to potential sources of raw materials in their immediate environment" - Application of new analytical, non-destructive X-ray techniques and Sr isotope measurements *Archeometriai Műhely* (electronic periodical: http://www.ace.hu/am/index.html), **2/2**, pp. 1-4.

Introductory paper for a two-year bilateral collaboration project between Tübingen University, and a number of Hungarian research centres on Early Neolithic pottery and regional soil and clay samples.

TAUBALD, H., T. BIRÓ, K., KASZTOVSZKY, ZS., BALLA, M. (2006, in press): Early Neolithic Pottery and its Environment in Hungary. Poster presented on *36th ISA Symposium*, Quebec. In press for conference proceedings.

Preliminary results from geochemical data provide interesting new facts about pottery production and possible raw materials from a selection of neolithic excavation sites throughout Hungary. Both, sediments and pottery can easily be distinguished by their geochemical composition. In places where the original soil was of good quality (mainly those in the East, Szarvas-Endröd, etc.) they used the clay rich variation of the local sediment, however, when the sediment was too sandy (e.g. Vörs) they used different sources (e.g. clay mine Batthyánpuszta in the nearer surroundings). Different sources always resulted in a higher variability of chemical pottery composition. On the other hand, for daub always the local sediment was used as it was, without any further pre-treatment. Apart from this it can be seen, that pottery is always enriched in Ba, P, Ti, Cr and Fe compared to local sediments (not shown in diagrams here). The reason for this phenomenon has to be discussed. The strong heterogeneity within Vörs pottery samples is probably due to different cultures at this site. The variation may be explained by use of temper from older cultures and different clay sources from the nearer and farer surroundings. The application of three different analytical methods proved the qualification of XRF, INAA and PGAA for the analyses of ceramic samples and raw materials.

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VARGA, I. (1989): Középkori mázatlan cserépkályhák természettudományos vizsgálata I. (Külsővat XV. századi kályhacsempéi). (Naturwissenschaftliche Überprüfung der mittelalterlichen Ofenkacheln I. (Ofenkacheln von Külsővat aus dem XV. Jahrhundert)). *Acta Musei Papensis, Pápai Múzeumi Értesítő*, **2**, pp. 141-148. (from ARH II.).

VARGA, I. (1995): Középkori mázatlan cserépkályhák természettudományos vizsgálata II. (Naturwissenschaftliche Untersuchung der mittelalterlichen unglasierten Kachelöfen II. („Lövenartige" Kacheln in Transdanubien)). *Acta Musei Papensis, Pápai Múzeumi Értesítő*, **5**, pp. 213-218. (from ARH II.).

VERŐ, J. (1984): A dénesfai vasolvasztó környékén végzett geofizikai mérések (Geophysical measurements at the iron smelting furnace in Dénesfalva). *Kohászat*, **117**, p. 539. (In Hungarian).

After a short description of the method used, the results obtained by the geomagnetic method at the Dénesfa furnace are described, including the pair of anomalies with a difference of about 60 nT at the furnace site. The considerable anomaly corresponds to a rather large quantity of magnetized slags, and the relatively stonger magnetization of the slags may be responsible for the negative anomaly, too. Other anomalies are due to recent iron objects, humic soil, in a few cases to the non-eliminated part of the time variation of the geomagnetic field. (from ARH I.).

WEISZBURG, T., PAPP, G. (1987): X-ray powder diffraction analyses. In: *Bezeczky, T. (ed.): Roman Amphorae from Amber Route in Western Pannonia*, BAR International Series, 386, Oxford, pp. 128-133.

X-ray diffraction study of powdered samples of 50 amphora fragments were carried out. The samples were collected from the Amber Roure and belonged to the types and workshops as follows: Dressel 2-4 (8 samples), Dressel 5 (2), Dressel 6B (40, from various workshops, with stamps of C. Laecanius Bassus, Calvia Crispinilla, with imperial stamps, or without any stamps).

The investigations gave information on the crystalline phases of the groundmass of the amphorae. Quartz, K-feldspar, plagioclase, mica, calcite, piroxene and gypsum were found in main or significant quantity. The analytical results are listed according to Dressel types and workshops. Groups were outlined on the basis of the presence and the ratio of some mineral components. The mineralogical composition of the samples (presence of primary calcite etc.) generally suggested a relatively low firing temperature. (from ARH II.).

ZIMMER, K., KARDOS, J**.,** KRISTON, L**.,** VÉRTES, A**.,** KOCSÁRDY, É**.,** KARMACSI, Á**.,** FLÓRIÁN, K**.** (1981): Római kori kerámiák komplex vizsgálata optikai emissziós színképelemzéssel, röntgendiffrakcióval, Mössbauer- és infravörös spektroszkópiával, valamint elektronsugaras mikroelemzéssel. (A complex study of Roman Age pottery by means of optical emission spectroscopy, X-ray diffraction, Mössbauer- and infra-red spectroscopy as well as electron probe microanalysis). *Proc. 24th Hung. Conf. on Spectral Analysis*, Miskolc, p. 137. (In Hungarian).

A collection of pottery vessels from a Late Roman Age cemetery at Pécel, near to Budapest, was investigated by a large variety of instrumental analytical methods. A team of scientists examined the advantages of X-ray diffraction, electron probe microanalysis, optical emission-, Mössbauer- and infrared spectroscopy in technology and provenance studies of pottery.

Firing tempetature is concluded from phase analysis by X-ray diffraction. Infra-red spectra of ceramic material represent changes during the firing process in the clay mineral structure. The use of Mössbauer spectroscopy is to obtain certain information about the firing atmosphere by studying iron compounds in the body of pottery. Multi-element trace analysis by optical emission spectroscopy is available for provenance studies, nevertheless the data processing needs multidimensional mathematical methods. The glossy grey or red layer on the surface of grey pottery and certain terra sigillata imitations is known to be due to the application of slip as surface coating. Comparison of the elemental composition of the surface and the body of pottery confirmed the presence of slip. Leaching processes from body to surface were traced by electron microprobe, as well. (from ARH I.).

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Abbreviations

Acta Arch. Hung.	Acta Archaeologica Academiae Scientiarum Hungaricae (Budapest)
Arch. Ért.	Archaeológiai Értesítõ (Budapest)
BAR	British Archaeological Reports (Oxford)
Folia Arch.	Folia Archaeologica (Budapest)
J. Arch. Sci.	Journal of Archaeological Science (London)
J. Radioanal. Nucl. Chem.	Journal of Radioanalytical and Nuclear Chemistry (Budapest, Amsterdam)
Mitt. Arch. Inst.	Mitteilungen des Archäologischen Instituts der Ungarischen Akademie der Wissenschaften (Budapest)
MTA VEAB Értesítő	MTA Veszprémi Akadémiai Bizottságának Értesítõje (Veszprém)
Nucl. Tracks Radiat. Meas	Nuclear Tracks and Radiation Measurements (Elsevier)
PACT Journal	PACT. Revue du Groupe Européen d'Études Pour les Techniques Physiques, Chemiques et mathémathiques Appliquées a l'Archéologie (Rixensart, Belgium)
VMMK	Veszprém Megyei Múzeumok Közleményei (Veszprém)

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